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(54) Title: PROTECTIVE COATING FOR BOAT HULLS AND METHOD OF APPLYING THE SAME

(57) Abstract

An improved, environnmentally safe protective coating for marine surfaces is provided which is specially formulated for application to boat hulls for resisting marine growth thereon while minimizing release of toxic antifoulants into the environment. The coatings of the invention can therefore be used on boat hulls for preventing marine growth without the severe pollution effects associated with conventional antifoulant paints. The coatings are preferably made from powdered mixtures which include respective quantities of a polyamide such as Nylon 11, and a metallic antifoulant. In certain cases, the compositions may include an inorganic porous carrier such as carbon black, as well as glass spheres. In particularly perferred embodiments, use is made of an antifoulant such as elemental tin or copper or mixtures thereof together with an adhesive and an algicide. Application of the mixture to marine surfaces involves providing a supersonic gas stream, passing the gas stream through an electric arc thereby heating the gas stream and converting a portion thereof to plasma, injecting a quantity of the powdered mixture into the heated gas stream substantially downstream from the arc so as to melt the powder without overheating it, and then spraying the melted mixture onto a surface whereupon it cools and provides a bonded protective coating thereon.

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PROTECTIVE COATING FOR BOAT HULLS AND METHOD OF APPLYING THE SAME

This is a Continuation-in-Part of identically titled application Serial No. 07/193,805 filed May 13, 1988.

Background of the Invention

1. Field of the Invention

The present invention is broadly concerned with a novel antifoulant coating for marine surfaces and a novel method for applying the coating to such surfaces. More particularly, it is concerned with a polyamide coating for boat hulls which in one embodiment preferably includes Nylon 11, carbon black and tributyltin fluoride for purposes of yielding a long lasting, marine growth resistant, environmentally safe coating for boat hulls. In other embodiments, the compositions of the invention advantageously includes a predominant amount of elemental copper or tin, together with a nylon terpolymer adhesive, an algicide and Nylon 11. The compositions are applied to provide a marine growth-resistant coating to a boat hull by providing an electric arc, directing a gas stream through the arc thereby heating the gas stream, injecting the powdered composition into the heated gas stream at a location downstream from the arc so as to melt the powder without overheating the same, and then applying the melted mixture to the surface to be coated.

2. Description of the Prior Art

Traditionally, high friction, abradable paints containing significant levels of antifoulants

have been applied to boat hulls to prevent marine growth ther on. Such paints sometim s contain in excess of 50% by weight of toxic antifoulants which leach to the surface of the paint, thereby retarding the formation of marine growths thereon. These conventional paints are also designed to gradually wear away as they are subjected to frictional forces encountered as the boat moves through water. This wearing away due to abrasion facilitates the gradual removal of marine growth from the boat and thereby continuously provides a new and growth-free paint surface on the boat hull.

Typical paint application techniques involve compressed air spraying of liquid paints onto prepared boat hull surfaces. Preparation usually involves cleaning of the hull surfaces, and in the case of surfaces which are being repainted, sanding or sandblasting is usually required in order to remove the old paint prior to repainting.

These traditional paints and paint application techniques have a number of problems or shortcomings. Abradable paints containing high levels of toxic, tin-based antifoulants result in substantial environmental pollution due to the direct and rapid release of large quantities of these antifoulants into the water. The environmental impact of these paints is intensified by the loss of tin containing paint particles into the water as a result of abrasion. Accumulation of tin in shallow waters can and does kill and deform fish and other marine life and may ultimately pose a hazard to human consumers of seafood. Furthermore, tin-based antifoulants have been used on aluminum boats to the exclusion of copper based antifoulants due in

part to a corrosive reaction between copper and aluminum which can cause extensive damage to aluminum surfaces. Additionally, boats coated with conventional paints must be occasionally blasted with high pressure water spray, which adversely affects the adherence of the paint to the hull, in order to remove built up deposits such as scale. Another shortcoming of many of these paints is that they are relatively shortlived, quickly becoming ineffective due to their tendency to rapidly leach their antifoulants and their propensity to experience substantial wear during use of the boat. As a consequence, conventional paints typically require relatively frequent removal and replacement. Removal of the old paint by techniques such as sanding and sandblasting can create substantial quantities of toxic paint dust which when inhaled can cause serious illness and when washed into surrounding waters can pollute the marine environment. Furthermore, conventional spraying techniques typically result in substantial paint overspray and misting which likewise can cause serious illness if inhaled.

Consequently, a need exists for improvement in antifoulant, protective coatings for marine surfaces which will result in reduced environmental pollution while at the same time providing a low maintenance, wear-resistant, protective coating which resists marine growth.

Summary of the Invention

The problems outlined above are in large measure solved by the present invention which provides an improved, long-lived, non-abrading, dense coating for marine surfaces which is particularly designed to be applied to marine surfaces such as

boat hulls, submarine hulls, and propellers, for purposes f preventing marin growth from forming thereon while minimizing environmental pollution and health hazards resulting from the coating. Broadly speaking, in one aspect of the invention, the coating composition comprises respective amounts of a polyamide in the nature of Nylon 10 or 11, an antifoulant, and preferably also an inorganic porous carrier for the antifoulant. These ingredients are selected and mixed so that the composition, when applied to a marine surface, will provide a marine growth resistant coating which is low friction, long lasting, wear-resistant and relatively environmentally safe. Advantageously, this resultant protective coating has an antifoulant release rate of less than 5 micrograms per square millimeter per day so as to minimize environmental pollution while at the same time maintaining a protective coating against marine growth. Therefore, the composition of the invention can be used to good effect in protecting boat hulls while providing a surface coating which experiences reduced wear, extended life, and reduced environmental impact.

Additionally, the present invention contemplates the application of tin- or copper-based antifoulants to aluminum boats by first coating the hull of the boat with a dense, protective precoat preferably about five to ten thousandths of an inch thick of Nylon 10 or Nylon 11 and then applying the antifoulant coating of the present invention thereon.

In particularly preferred forms, the composition of the invention includes Nylon 11, carbon black, and tributyltin fluoride antifoulant. However, other forms of nylon (e.g. Nylon 10) as

well as other antifoulants (e.g., cuprous oxide and bis-tributyltin adipate, $C_{30}H_{62}O_4Sn$) find utility in the invention. Porous inorganic powered substitutes of carbon black which serve as a carrier for the antifoulant (e.g., perlite, zinc oxide, various paint clays and pigments) also can be used in the invention. In yet another form, the composition of the invention may include a portion of SiO_2 glass spheres. The glass spheres do not melt when combined and sprayed with the polyamide coating as disclosed herein and imbed in the antifoulant coating to increase the strength and abrasion resistance of the antifoulant coating hereof.

In other preferred compositions, elemental tin or copper in particulate form (49 microns or less) is employed in substantial amounts ranging from about 72% by weight up to an amount which would render the composition effectively electrically conductive, in combination with a polyamide such as Nylon 10, Nylon 11 or mixtures thereof. In practice, the particulate, elemental tin or copper is provided at a level of from about 72-82% by weight. Such compositions further normally include from about 4-8% by weight of a nylon terpolymer adhesive, about 4-8% algicide, with the balance being a polyamide such as Nylon 11.

In coating application techniques, the powdered compositions of the invention may be injected into a high velocity, heated, plasma gas stream which converts the powdered compositions to a molten state and imparts a high velocity thereto. The molten compostions and associated gas are then directed into substantially one direction thereby reducing any tendency of the molten compositions to overspray or mist. The molten compositions are di-

rect d at a prepar d marin surfac , whereupon they cool and bond with the marine surface. High velocity impact of the molten compositions onto the marine surface increases the bond strength therebetween. The resultant bonded polyamide coating is wear-resistant, contains relatively small amounts of antifoulant and leaches the antifoulant relatively slowly, but at a rate sufficient to retard marine growth thereon. Prior techniques and structures for the application of polyamides or epoxy resins by plasma spray are set out in U.S. Patents No. 3,851,140 and 4,049,842.

In addition to the aforementioned advantages, the coatings hereof have relatively low coefficients of friction and as a result will reduce the noise, drag and energy needs of the boat as it moves through the water. Subsequent coatings can be applied onto the existing coatings without a substantial sacrifice in the bond strength of the resultant coatings. Thus, new coatings can be applied without necessitating the removal of previous, exhausted coatings. One additional aspect of the present invention is that the total antifoulant content of the coatings can be reduced by applying antifoulant-free Nylon 11 undercoats prior to applying an outer antifoulant-containing final coat.

In addition, the present invention contemplates providing a skid-proof coating by combining and jointly plasma spraying a friction enhancing agent such as particles of aluminum oxide along with Nylon 11 and/or the antifoulant composition of the present invention.

The protective coatings disclosed herein may be applied using the apparatus shown in my U.S.

Application Serial No. 07/193,739 filed May 13, 1988, and such application entitled Apparatus and Method for Applying Plasma Flame Sprayed Polymers, which is incorporated herein by reference.

Description of the Preferred Embodiments

One preferred polyamide coating in accordance with the present invention includes about 82% by weight of Nylon 11, about 6% by weight of carbon black, and about 12% by weight of tributyltin fluoride. This composition is initially in the form of a powdered mixture and is subsequently melted for application to a marine surface whereupon it cools and forms a dense, impact resistant coating.

In its broader aspects, this embodiment of the invention comprehends coating compositions having from about 62.5 to 82% by weight of polyamide selected from the group consisting of Nylon 10, Nylon 11 and combinations thereof, and more preferably from about 70 to 82% by weight thereof; from about 25 to 60% by weight antifoulant such as tin or copper-based antifoulant materials, and preferably from about 25 to 37% by weight thereof; and from about 6 to 12% by weight porous inorganic carrier powder selected from the group consisting of carbon black, zinc oxide and perlite, and more preferably from about 8 to 12% thereof.

Nylon 11, also known as poly[imino (1-oxo-1, 11-undecanediyl)], is a polyamide having the chemical formula $H[HN-(CH_2)_{10}-CO]_nOH$ where n is approximately 50. The present invention also contemplates using various other forms of poly[imino (1-oxo-1, 11-undecanediyl)] including those where n is from 25 to 100. Nylon 11 can be obtained by the

self c nd nsation of w-amino und canoic acid or can be obtained as a condensate of hexamethylene diamine and w-amino undecanoic acid. This polyamide comes in various grades of powder, has a melting point of 184 to 186°C, a bulk density of approximately .4 to .5 and a true density at 20°C of approximately 1.04 to 1.12. Nylon 11 is available commercially, and in actual practice may be obtained from Atochem, Inc. of Glenrock, New Jersey, under the trade name Rilsan. Nylon 10 is a powdered, polyamide having the chemical formula $H[HN-(CH_2)_9-CO]_nOH$ where n is preferably from about 25 to 100 and more preferably about 50. Nylon 10 is also available commercially.

Tributyltin fluoride is an antifoulant having a chemical formula $(C_4H_9)_3SnF$. Tributyltin fluoride has a specific gravity of 1.27, and a molecular weight of 309.39, a solublity in water of .029 grams per liter and at room temperature is a white powder having a characteristic odor. Tributyltin fluoride is available commercially, and in actual practice may be obtained from M & T Chemicals, Inc. of Rahway, New Jersey.

Another suitable antifoulant contemplated by the present invention is cuprous oxide having the formula Cu_2O. Cuprous oxide, also known as copper oxide red, is in the form of reddish brown, octahedral crystals which are insoluble in water, have a density of 5.75 to 6.09, and a melting point of 1,235°C. Cuprous oxide is available commercially, and in actual practice may be obtained from American Chemet Corporation.

Carbon black is a porous inorganic powder and in the present invention is used to increase the amount of antifoulant which can be carried by the

polyamide and to increase the rate of leaching of the antifoulant from the polyamide. Carbon black, due to its porosity, serves to both carry the antifoulant and increase the porosity of the polyamide. Carbon black also serves to prevent powdered tributyltin flouride from "balling up" thereby enhancing the flowability of the premelt powdered mixture. A usable form of carbon black is gas black which is a fluffy black pigment produced by incomplete combustion of natural gas. Another usable form of carbon black is furnace black which is a finely divided form of carbon made by burning vapor and heavy oil fraction in a furnace at 50% of the air required to complete combustion. Other forms of carbon black also find utility. The preferred carbon black product is purchased from Union Carbide. Another suitable porous inorganic carrier is perlite which is known as the eutectic between ferrite and cemetite and has a laminar structure resembling mother-of-pearl, barely resolvable under the finest microscopes, and occurs in steel as a result of the transformation of austenite into aggregations of ferrite and cementite. Perlite is commercially available, and in actual practice may be obtained from Borget Brothers, Santa Monica, California.

Zinc oxide (ZnO) is another carrier contemplated by the present invention. Zinc oxide is a coarse white or grayish powder which is odorless and has a density of 5.47 g/cm^3 and a melting point of 1975°C. Zinc oxide is commercially available and in actual practice may be obtained from TRI-ESS Sciences, Burbank, California.

Th composition hereof may include a portion of hollow, SiO_2 glass spheres of a controlled particle size and density. The spheres are preferably 0.60 grams per cubic centimeter in density and average 65 to 75 microns in diameter. The hollow spheres act as microscopic bearings with a minimum ratio of surface area to volume, thereby reducing viscous drag, resisting abrasion to the surface and providing improved flow properties. The hollow spheres comprise .20% by volume of the polyamide coating, and may be provided with a copper coating when, for example, the composition hereof includes a portion of cuprous oxide or other copper-based antifoulant. The glass spheres are available commercially, and in actual practice may be obtained from the 3-M company of St. Paul, Minnesota under the name "Glass Bubbles.", either with or without a copper coating.

In preferred production procedures, the powdered compositions in accordance with the invention are prepared by thoroughly mixing respective powdered amounts of the polyamide, the porous inorganic carrier, and the antifoulant. Preferably, the powder is prepared by mixing respective amounts of agglomerates of carbon black and tribultyltin flouride in a Hobart Blender at 3600 RPM for 2 minutes, homogenizing this mixture into powder of a size of approximately 325 Mesh (120 microns), and then mixing respective amounts of these pellets, Nylon 11 and glass spheres.

In another aspect of the invention, compositions are provided including relatively large quantities of antifoulant such as elemental tin or copper or cuprous oxide, and a polyamide such as Nylon 10, 11, or 12-12. Such compositions also

normally include minor amounts of adhesive and algicid . Thus, a pref rred composition may include from about 54%-82% by weight of elemental tin or copper (most preferably about 82% by weight) of a particle size preferably less than 49 microns, about 4-8% of an adhesive (advantageously about 4% by weight of a nylon terpolymer/caprolactam adhesive sold under the designation "M548" by Atochem, Inc. of Birdsboro, Pennsylvania) of a particle size preferably less than 150 microns, from about 4-8% of an algicide (preferably about 4% by weight of a material sold under the designation "VANCIDE 89" by the R.T. Vanderbilt Company, Inc. of Norwalk, Connecticut, which is N-trichloromethylthio-4-cyclohexene-1,2-dicarboximide) of a particle size preferably of 5 microns or less, and with the balance being Nylon 11 or alternatively, Nylon 12-12 manufactured by E.I. DuPont de Nemours and Company of Wilmington, Delaware. The Nylon 11 or other polyamide preferably is of a particle size of 150 microns or less. This preferred composition has been found to be extremely effective, and is particularly advantageous from an ecological standpoint in that it has a leach rate of less than 1 microgram of antifoulant per square millimeter per day. Furthermore, use of elemental tin or copper avoids the handling problems inherent in the use of tributyltin antifoulants.

Other compositions within the ambit of the invention may include from about 40 to 70% by weight cuprous oxide (preferably about 52% by weight, about 4-8% by weight of adhesive (preferably about 4% by weight of nylon terpolymer adhesive), about 8% by weight of the "VANCIDE 89" material, and with the

balance being ither Nylon 10, Nylon 11, Nylon 12-12, or mixtur s thereof.

Here again, the above-described compositions are prepared by mixing the metallic anti-foulant, adhesive and algicide in a conventional blender, such as a Hobart blender. Such powdered particles are then blended for two to three minutes at 3600 r.p.m.'s with the polyamide to provide the final coating composition which, after blending, has preferably a mesh size of about 44 microns.

Preferred techniques for applying the coating compositions of the present invention include the steps of providing a high velocity flow (i.e., about Mach I or above) of a gas such as pure argon; passing the gas transversely through an elongated high wattage electric arc for heating the gas and converting a portion thereof to the plasma state; injecting the powdered coating composition into the gas downstream from the arc for melting the powder without overheating the powder; directing the flow of the composition and associated gas into substantially one direction for minimizing overspray and misting of the composition; and spraying said melted composition onto a surface to be coated. More preferably, the powdered composition is injected into the gas stream in a downstream direction and at an angle of from about 12 to 20° to the direction of flow of the stream; and most preferably the powdered composition is injected in a downstream direction and at an angle of about 18° to that of the direction of travel of the gas stream so as to minimize vortex formation within the stream and minimize the over spray associated with vortex formation. Also more preferably, the powder is injected at a distance of from about 6 to 10 inches

downstream from the arc (the arc being defined as a point of energy transfer betwe n an anode and a cathode) so as to minimize overheating of the composition and so as to ensure that the composition reaches maximum velocity for a corresponding maximum bond strength with the surface to be coated; and more preferably, injecting the composition into the gas stream at a location of from about 5 to 8 inches downstream from the arc so as to achieve the proper molten state of the composition and a particle velocity favoring interatomic bonding of the composition with the surface to be coated.

If injection of the powdered composition is made either through a high wattage arc or closely adjacent thereto, the composition will be overheated and rendered useless. If a lower wattage arc is employed so as to generate a temperature low enough to permit injection of the powder either through the arc or adjacent thereto, then the application rate permitted by the arc will be so low as to make large scale application economically infeasible. Thus, injection of the powdered composition substantially downstream from the arc is advantageous to achieve an economically feasible, high volumetric rate application technique. Also, injection of the powder downstream from the arc permits increased arc temperature, which in turn permits adequate heating of increased flows of gas thereby permitting adequate melting and particle velocity for increased powder flow rates.

Plasma spraying has been used in the past in the context of spraying either ceramics or powdered metals but such materials do not have the temperature limitations of polyamide coatings. The present invention represents applying powdered

polyamide compositions involving injection of the powder at a sufficient distance downstream from the arc so as to achieve for the first time, high volumetric application rates of polyamide coatings.

The arc used in the method of the present invention has a preferred power level of 20 to 40 kilowatts and an associated gas temperature at the arc of approximately 12,000 to 30,000°F. The gas is then cooled so that by the time the gas has reached the inlet for the powdered composition, the temperature of the gas has dropped down to approximately 250 to 800°F while travelling at a speed of 5,000 to 7,000 feet per second. Gases useful in this invention include N_2, H_2, He, Ar and combinations thereof. The coatings made from the composition of the present invention when applied using the application techniques of the present invention provide coatings having application rates, densities and bond strengths substantially greater than that of coatings applied by conventional polyamide application techniques such as fluidized bed dipping, acetylene flame spraying and electrostatic spraying.

The plasma spray method of the present invention further involves vacuuming toxic fumes from a periphery of the stream adjacent the surface to be sprayed for minimizing the escape of toxic fumes generated during heating of the composition, into the atmosphere. Vacuumed gases are oil filtered to remove the toxic gas fumes and organic acid vapors. The vacuum preferably pulls at a rate of at least 10 inches of water at 85 and preferably 360 cubic feet per minute.

In coating a marine surface such as an aluminum boat hull, the hull may be treated in a stepwise fashion. That is, the hull may first be

precoated as set forth hereinabove by injecting a powdered polyamide selected from the group of Nylon 10 and Nylon 11 into the heated gas stream to melt the polyamide. The polyamide thus melted is then applied to the hull by directing the heated gas stream toward the surface of the hull. The polyamide coating thus applied is permitted to melt to form a precoat. The polyamide precoating is then sprayed with an antifoulant coating mixture including an antifoulant and a polyamide such as Nylon 10 or Nylon 11. The antifoulant coating mixture is similarly injected into a gas stream which has passed through an electric arc thereby melting the antifoulant mixture. The melted antifoulant coating mixture is then applied over the precoat and allowed to cool therein, producing a final antifoulant coating on the aluminum hull.

A skid resistant coating may also be applied according to the method disclosed herein. The coating includes respective amounts of Nylon 10 or Nylon 11, or combinations thereof, and a portion of solid particles of aluminum oxide, which are not melted during the injection of the compositions in the heated gas stream.

The following example sets the preferred preparation of a powdered composition in accordance with the present invention, together with typical steps involved in application of the coating.

EXAMPLE

A premelt powdered coating composition is prepared by mixing 6 pounds of carbon black with 12 pounds of tributyltin fluoride in a Hobart Blender at 3600 RPM for 2 minutes. This serves to blend and

h mogeniz the mixture into p wdered particles of a size f approximately 325 mesh (120 microns). Such powdered particles are then mixed with 82 pounds of powdered Nylon 11 for two to three minutes at about 3,600 r.p.m.'s.

A directed stream of pure argon gas, at a flow rate of 1.42 cubic feet per minute (CFM) at 50 psi, is passed transversely through an electric arc having a power level of 12 kilowatts. The arc substantially heats the gas and causes some of the gas to be converted to the plasma state. This heated stream is then cooled as it moves away from the arc. The powdered composition mixture is then injected by use of a pressurized carrier gas into the heated gas stream at a location of about 8.5 inches downstream from the arc and in a downstream direction and at an angle of about 18° to that of the general flow of the gas stream. The mixture and the heated gas then combine to properly melt the mixture and impart a substantial velocity onto the melted mixture. The gas and mixture then are passed further downstream together in a substantially uniform direction so as to minimize overspray and are then sprayed directly onto a marine surface so as to form a film coating of the composition thereon. The film coating is then allowed to cool and bond with the surface.

Claims

1. A polyamide powdered mixture comprising an amount of a polyamide powder selected from the group consisting of Nylon 11, Nylon 10, and combinations thereof; and an amount of an antifoulant, said mixture, upon melting, application to a marine surface and cooling thereon, providing a low friction, growth resistant, non-abrading coating.

2. The mixture of Claim 1, said antifoulant being selected from the group consisting of tin-based antifoulants and copper-based antifoulants.

3. The mixture of Claim 2, said mixture further comprising porous inorganic carrier.

4. The mixture of Claim 3, said mixture further comprising a portion of SiO_2 glass spheres.

5. A polyamide, powdered mixture comprising an amount of a polyamide powder selected from the group consisting of Nylon 11, Nylon 10, and combinations thereof; an amount of an inorganic porous carrier; and an amount of a tin based antifoulant, said mixture, upon melting, application to a marine surface and cooling thereon, providing a low friction, growth resistant, non-abrading coating, said antifoulant being released from said coating into the marine environment at a rate of less than 5 micrograms per square millimeter of coating surface per day.

6. The mixture of Claim 5, said anti-foulant being tributyltin fluoride.

7. The mixture of Claim 5, said inorganic carrier being carbon black.

8. The mixture of Claim 5, said polyamide being Nylon 11.

9. The mixture of Claim 5:
said polyamide being present at a level of from about 45 to 60% by weight;
said inorganic carrier being present at a level from about 15 to 18% by weight; and
said antifoulant being present at a level from about 25 to 37% by weight.

10. The mixture of Claim 4, said mixture further comprising a portion of SiO_2 glass spheres.

11. The mixture of Claim 10: said glass spheres being present at a level of .20% by volume.

12. A powdered, coating mixture comprising:
from about 63 to 82% by weight of Nylon 11;
from about 6 to 12% by weight of carbon black; and
from about 12 to 25% by weight of tributyltin fluoride.

13. A polyamide, powdered mixture comprising an am unt of a polyamid powd r selected from the group consisting of Nylon 11, Nylon 10, and combinations thereof; and an amount of a copper based antifoulant, said mixture, upon melting and application to a marine surface and cooling thereon, providing a low friction, growth resistant, non-abrading coating thereon.

14. The mixture of Claim 13, said antifoulant being selected from the group consisting of elemental copper and cuprous oxide.

15. The mixture of Claim 14, said mixture further comprising a portion of SiO_2 glass spheres, said spheres being provided with a copper coating.

16. A method of applying a protective coating to a marine surfaces comprising the steps of:

providing an electric arc;

directing a high velocity gas stream through said arc thereby heating said gas stream;

injecting a powdered mixture into said heated gas stream, said powdered mixture comprising an amount of a polyamide selected from the group consisting of Nylon 11, Nylon 10, and combinations thereof; and an amount of an antifoulant, at a location substantially downstream from said arc whereby to melt said powdered mixture without overheating said powdered mixture; and

applying said melted mixture to said surface.

17. The method of Claim 16, wherein said powdered mixture includes a quantity of an inorganic porous carrier.

18. The method of Claim 17, wherein said inorganic porous carrier is carbon black.

19. The method of Claim 16, wherein said gas is selected from a group consisting of Ar, N_2, H_2, He and combinations thereof.

20. The method of Claim 16, wherein the flow of said gas and said powdered mixture are directed in a substantially uniform direction following injection of said powdered mixture into said gas stream.

21. The method of Claim 16, wherein said arc has a power level of 20 to 40 kilowatts.

22. The method of Claim 16, wherein said gas stream is heated to a temperature of about 12,000 to 30,000°F.

23. The method of Claim 16, wherein said melted mixture reaches a maximum temperature of from about 250 to 800°F.

24. A method of coating a marine surface, comprising the steps of precoating said surface with a polyamide selected from the group consisting of Nylon 10 and Nylon 11, said precoating including the steps of melting said polyamide, applying said melted polyamide to said surface and allowing said melted polyamide to cool thereon thereby forming a precoat; and coating said precoat with a mixture comprising an amount of a polyamide powder, selected from the group consisting of Nylon 10, Nylon 11, and mixtures thereof, and an amount of an antifoulant, said coating including the steps of melting said mixture, applying said melted mixture to said precoat and allowing said melted mixture to cool thereon.

25. A skid resistant coating comprising respective amounts of a polyamide selected from the group consisting of Nylon 11, Nylon 10, and combinations thereof; and solid particles of aluminum oxide.

26. The mixture of Claim 1, said antifoulant being selected from the group consisting of elemental tin, elemental copper and mixtures thereof.

27. The mixture of Claim 26, said antifoulant being present at a level of from about 72% by weight up to the amount thereof which would render the mixture effectively electrically conductive.

28. The mixture of Claim 26, including an amount of a synthetic resin adhesive.

29. The mixture of Claim 28, said adhesive comprising a nylon terpolymer based adhesive and being present at a level of from about 4% to 8% by weight in said composition.

30. The mixture of Claim 26, including an amount of an algicide.

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US89/02056

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(4): C08L 77/02; C08K 3/22; B05D 3/06

US. CL: 523/122; 427/37; 524/430

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
US	523/122, 606 427/37 524/430

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	US, A, 3,988,287 (INOKUCHI) 26 OCTOBER 1976. SEE COL. 1, LINES 54-65;	25
X	US, A, 3,833,534 (TIERNEY ET AL) 03 SEPTEMBER 1974. SEE COL. 3, LINES 54-64; COL. 6, LINES 43-45 AND 56-63.	25
Y	US, A, 4,689,364 (MUMCU ET AL) 25 AUGUST 1987. SEE COL. 3, LINES 35-51; COL. 4, LINES 19-30.	1-8, 10
Y	US, A, 3,861,949 (ONOZUKA ET AL) 21 JANUARY 1975. SEE COL. 2, LINES 31-50, COL. 7, LINES 60-68 AND COL. 8, LINES 1-15.	1-8, 10
Y	GB, A, 2,099,444 (JENSON ET AL) 08 DECEMBER 1982. SEE PAGE 1, LINES 60-64; PAGE 2, LINES 9-16.	1-8, 10
A	US, A, 3,947,607 (GAZZARD ET AL) 30 MARCH 1976. SEE ENTIRE DOCUMENT.	11-24
A	US, A, 4,197,233 (MARSHALL) 08 APRIL 1980. SEE ENTIRE DOCUMENT.	26-30

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
30 AUGUST 1989	28 SEP 1989
International Searching Authority	**Signature of Authorized Officer**
ISA/US	L. T. JACOBS

International Application No. PCT/US89/02056

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SEC ND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
A	US, A, 4,410,642 (LAYTON) 18 OCTOBER 1983. SEE ENTIRE DOCUMENT.	26-30
A	US, A, 4,701,518 (OSBORN ET AL) 20 OCTOBER 1987. SEE ABSTRACT.	30